42. (Amended) A method for removing or reducing the concentration of a halocarbon compound in a sample, comprising contacting a sample suspected of containing said halocarbon with a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria, or contacting said site with a device comprising a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria.

56. (Amended) A method for reducing the concentration of a pesticide or organic pollutant in an aqueous solution or environmental site, comprising (a) selecting an aqueous solution or an environmental site containing said pesticide or pollutant; and (b) contacting said solution or site with a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria, or contacting said solution or site with a device comprising a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria.

II. RESPONSE TO OFFICE ACTION

A. Status of the Claims

Claims 1-18, 34-37 and 42-58 are pending. Claims 46-58 are allowed. Claims 9-12 are objected to as being dependent upon a rejected base claim but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. Claims 1, 42, and 56 have been amended to more clearly point out the present invention. Claims 9 and 11 have been amended herein to include all the limitations of the base claim and any intervening claims and so render claims 9-12 allowable.

Support for the amendments to the claims may be found throughout the examples, the specifications and the claims as originally filed. Support for amendments may be found on page

17, lines 8-9; page 18 lines 20-21; page 19 lines 5-9; page 26; and page 28 lines 8-11. No new matter has been added.

For the Examiner's convenience, a marked copy of the amendments to the claims is provided in Appendix A and a clean copy of the pending claims after amended is provided in Appendix B. Appendix C contains a clean copy of the abstract.

B. Claim rejections under 35 U.S.C. 102(b)

1. The Legal Standard of Novelty under 35 U.S.C. 102(b).

To anticipate the claimed invention, a single prior art reference must expressly or inherently disclose each and every element as set forth in the relevant claim or claims. *Verdegaal Brothers, Inc. v. Union Oil Co.*, 814 F.2d 628, 631-33 (Fed. Cir.), *cert denied*, 484 U.S. 827, 108 S. Ct. 95, (1987). If all elements of the claim are met, but only if all elements are met, is the claim expressly anticipated. *Atlas Powder v. Ireco Inc.*, 190 F.3d 1342, 1346, 51 USPQ2d 1943, 1945 (Fed. Cir. 1999). These elements must be arranged as in the claim under review, although this is not an "ipsissimis verbis" test. *In re Bond*, 910 F2d 831,15 U.S.P.Q.2d 1566,1568 (Fed. Cir. 1990).

2. Claims 1-2, 5-8, 13-18, 36-37 and 56 are Novel under 35 U.S.C. 102(b) in view of Asahi.

Claims 1-2, 5-8, 13-18, 36-37 and 56 are rejected under 35 U.S.C. 102(b) as being anticipated by Asahi (JP 52-130150). The Applicants respectfully traverse.

The Action contends that Asahi is directed toward a device comprising iron and hydrogenotrophic bacteria and teaches a device having powdered iron compounds and *Pseudomonas* or *Micrococcus* species bacteria supported on a resin support, wherein the device

is contained in a packed column bioreactor for treating sulfate-containing water, wherein the solution inherently is selected since the solution must be placed into the device for treatment.

However, Applicants respectfully point out that Asahi does not teach a zero-valent iron but rather an iron flock. See pages 1, first paragraph; page 2, paragraphs 2 and 3; and page 4, paragraph 3 of Asahi. Asahi clearly states "The iron flock used in the present invention is non-soluble ferrous compound such as iron oxide or iron hydroxide....." Furthermore, Asahi expressly discloses the use of organic carbon as an energy source. See Asahi, at page 5, paragraph 2.

In contrast, the present invention provides iron supported autotrophic bacteria in a device comprising a composition containing zero-valent iron. See the present claims and the specification, page 9 lines 18-20, page 26 lines 10-12 and the Examples on pages 38-60. The Applicants' invention expressly provides for compositions that support an autotrophic process. See the specification, pages 9, line 19; page 28 lines 8-11; page 48, lines 26 to 28.

Applicants respectfully submit that Asahi does not anticipate the present invention since Asahi does not teach or disclose a device comprising a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria. Thus, Asahi does not provide all of the elements of the Applicants' present invention, as is required under 35 U.S.C. 102.

In light of the foregoing, Applicants respectfully request that the Examiner reconsider and withdraw the rejection of claims 1-2, 5-8, 13-18, 36-37 and 56 under 35 U.S.C. 102(b) as being anticipated by Asahi (JP 52-130150).

3. Claims 1, 5-8, 13-18, 34-35 and 56 are Novel under 35 U.S.C. 102(b) in view of Kanatsuki.

Claims 1, 5-8, 13-18, 34-35 and 56 are rejected under 35 U.S.C. 102(b) as being anticipated by Kanatsuki (JP 2-119992). The Applicants respectfully traverse the rejection.

The Action contends that Kanatsuki is directed toward a device comprising iron and hydrogenotrophic bacteria and teaches a device having pellet iron compounds and hydrogenotrophic bacteria supported on a zeolite support, wherein the device may be used in a packed-column bioreactor for treating water *ex situ* remediation, wherein the solution inherently is selected since the solution must be placed into the device for treatment.

Applicants respectfully point out that Kanatsuki does not teach the present claim element of a zero-valent iron. Furthermore, Kanatsuki discloses the mixing in of a carbon source. See claims 1-3 in Kanatsuki (JP 2-119992). Indeed, Kanatsuki teaches the use of a high carbon ratio of compounds for mixing in. See pages 4, paragraph 2; page 5, paragraph; page 7, paragraph 3; and page 17, paragraph 1. Thus, Kanatsuki clearly teaches a heterotrophic process. Kanatsuki also teaches the use of iron as an oxygen scavenger and proposes the use of iron ions that are produced during the corrosion process to enhance the precipitation of phosphates. See page 7, paragraph 1 and page 10, paragraph 3.

In contrast, the present invention provides iron supported autotrophic bacteria in a device comprising a composition containing zero-valent iron. See the present claims and the specification, page 9 lines 18-20, page 26 lines 10-12 and the Examples on pages 38-60. Applicants' invention provides autotrophs, which do not require the addition of a carbon source. Applicants' invention provides iron as an energy source. See page 26 lines 10-12; page 28 lines 8-11 and Example 2 on page 48 of the specification which provides details of Fe(0) of the

Applicants' invention as an electron donor and energy source. The Applicants' invention therefore expressly provides for compositions that support an autotrophic process. See the specification, pages 9, line 19; page 28 lines 8-11; page 48, lines 26 to 28.

Applicants respectfully submit that Kanatsuki does not anticipate the present invention since Asahi does not teach or disclose a device comprising a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria. Thus, Kanatsuki does not provide all of the elements of the Applicants' present invention, as is required under 35 U.S.C. 102.

In light of the foregoing, Applicants respectfully request that the Examiner reconsider and withdraw the rejection of claims 1, 5-8, 13-18, 34-35 and 56 under 35 U.S.C. 102(b) as being anticipated by Kanatsuki (JP 2-119992).

4. Claims 1, 5-7, 42-45, and 56 are Novel under 35 U.S.C. 102(b) in view of Weather *et al.* (C39).

Claims 1, 5-7, 42-45, and 56 are rejected under 35 U.S.C. 102(b) as being anticipated by Weathers *et al.* (Applicants' reference C39). Applicants respectfully traverse the rejection.

The Action contends that Weathers *et al.* discloses a device comprising iron and hydrogenotrophic bacteria, and teaches a device having zero-valence iron in the form of steel wool and hydrogenotrophic bacteria, wherein the device may be used to degrade halocarbons including carbon tetrachloride and wherein the solution inherently is selected since the solution must be placed into the device for treatment.

However, Applicants respectfully point out that Weathers *et al.*, does not teach, disclose or make reference to any device, particularly a device as is claimed in the Applicants' invention. In particular, Weathers *et al.*, does not disclose a device of claim 1, which recites "A device

comprising a composition comprising zero-covalent iron and a culture of one or more autotrophic hydrogenotrophic bacteria." Thus, Weathers *et al.*, does not anticipate claim 1.

The Action further contends that Weathers *et al.*, anticipates claim 7. Claim 7 recites "A device of claim 1, further comprising a support". Applicants argue that Weathers *et al.*, does not teach a device as in claim 7 comprising a support therefore, Weathers *et al.*, does not anticipate claim 7.

The Action also contends that claims 42 is anticipated by Weathers *et al.* Claim 42 recites "A method for removing or reducing the concentration of a halocarbon compound in a sample, comprising contacting a sample suspected of containing said halocarbon with a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria, or contacting said site with a device comprising a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria." As noted above, for a prior art to anticipate, every element of the claimed invention must be identically shown in a single reference. Applicants contend that claim 42 as amended is not anticipated by Weathers *et al.* because the reference does not disclose all the elements of claim 42.

The Action further contends claims 43-45 are anticipated by Weathers *et al.* Applicants respectfully note that Weathers *et al.* disclose the remediation of only chloroform and does not teach the claimed invention of claims 43-45. Claims 43-45 recite, respectively, "The method in accordance with claim 42, wherein said halocarbon is carbon tetrachloride, dichloromethane, a polychlorinated biphenyl, a chlorinated benzene, trichloroethylene, perchloroethylene, dichloroethylene, vinyl chloride, chloroethane, bromoform, dichlorodifluoromethane, trihalomethanes, tetrachlorodibenzodioxin pentachlorophenol, a chlorobenzoate, atrazine, or

1,1,1-TCA; "The method of claim 43, wherein said halocarbon is carbon tetrachloride, dichloromethane, trichloroethylene, perchloroethylene, dichloroethylene, vinyl chloride, chloroethane, dichlorodifluoromethane, trihalomethanes, tetrachlorodibenzodioxin pentachlorophenol, a chlorobenzoate, atrazine, or 1,1,1-TCA;" and The method of claim 44, wherein said halocarbon is carbon tetrachloride, trichloroethylene, or dichloromethane." Claims 43-45 do not contain the limitation that chloroform be the subject of remediation by the claimed compositions. Applicants therefore respectfully submit that claims 43-45 are not anticipated by Weathers *et al.*

The Action also contends that claim 56 is anticipated by Weathers *et al.* Claim 56 recites "A method for reducing the concentration of a pesticide or organic pollutant in an aqueous solution or environmental site, comprising (a) selecting an aqueous solution or an environmental site containing said pesticide or pollutant; and (b) contacting said solution or site with a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria, or contacting said solution or site with a device comprising a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria."

Applicants respectfully point out that Weathers *et al.* does not expressly or inherently teach or disclose each and every element of claim 56. Weathers *et al* does not teach the selecting or contacting steps of the method of claim 56 as recited in (a) and (b) of claim 56. Applicants also respectfully note that for a reference to anticipate via inherent properties, the reference "must make clear that the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill." *Continental*

Can Co. v. Monsanto Co., 948 F.2d 1264, 1268, (Fed. Cir. 1991). Applicants respectfully submit that such is not the case here.

Therefore, in light of all of the foregoing, Applicants respectfully request that the Examiner reconsider and withdraw the rejection of claims 1, 5-7, 42-45, and 56 under 102(b) as being anticipated by Weathers *et al.* (C39).

5. Claims 1-3, 5-8, 13-18, 35, 42-45, and 56 are Novel under 35 U.S.C. 102(b) in view of Weathers (C38).

Claims 1-3, 5-8, 13-18, 35, 42-45, and 56 are rejected under 35 U.S.C. 102(b) as being anticipated by Weathers (Applicants' reference C38). Applicants respectfully traverse the rejection.

The Action contends that Weathers is directed toward a device comprising iron and hydrogenotrophic bacteria, and teaches a device having powdered zero-valence iron or steel wool and *Pseudomonas* or *Micrococcus* species hydrogenotrophic bacteria, wherein the device may be used to degrade halocarbons including carbon tetrachloride and wherein the solution inherently is selected since the solution must be placed into the device for treatment.

Applicants respectfully note that Weathers does not teach or disclose a device as is claimed in claim 1. Rather, Weathers discloses the use of serum bottles and small column reactors. Furthermore, Weathers does not disclose any of the bacteria species of claims 2 or 3. Rather, Weathers teaches an uncharacterized acetate enrichment culture, -- a so-called "mixed culture." See Weathers, chapter 3, page 54-60 and throughout the entire dissertation. Weathers never makes any particular reference to what the "mixed culture" comprises. The Applicants thus, contend that Weathers does not anticipate claim 1 and the claims depending therefrom

since Weathers does not expressly or inherently disclose each and every element set forth in the claims.

The Action further contends that Weathers anticipates claim 7. Claim 7 recites "A device of claim 1, further comprising a support". Applicants argue that Weathers does not teach a device as in claim 7 comprising a support. Therefore, Weathers does not anticipate claim 7.

The Action further contends that claim 8 is anticipated by Weathers. Applicants respectfully submit that Weathers does not teach all of the elements of the claim 8, which recites "The device of claim 7, further comprising a glass, concrete, metallic, zeolite, mineral, fiber, fiberglass, ceramic, plastic, polymeric or resin support. Chapter 3 of Weathers (page 54-60) provides the details of the materials and methods used, however, there is no disclosure of a support in this chapter of Weathers as is claimed in claim 8. The Applicants therefore contend that Weathers does not anticipate claim 8 of the invention.

The Action further contends that Weathers anticipates claims 13-18. Applicants respectfully submit that claims 13-18 are not anticipated by Weathers. Weathers does not teach a device of claims 13-18. Claim 13 recites "The device of claim 1, further defined as an *ex situ* bioreactor." Throughout Weathers' disclosure there is no disclosure of a device as claimed in claims 13-18. Weathers does not teach "The device in accordance with claim 13, comprising an inlet port, an outlet port and a container means for containing said composition" as in claim 14, nor each and every element of claims 15-18. Applicants also contend that Weathers does not specify a device as in the claimed invention. Applicants further contend that Weathers does not anticipate claims 13-18 of the invention.

The Action also contends that claim 35 is anticipated by Weathers. Applicants respectfully submit that Weathers does not disclose a method for denitrifying of groundwater as

in claim 35, which recites "A method for denitrifying groundwater or an environmental site *in situ* comprising contacting said groundwater or said environmental site with a composition comprising zero-valent iron and a culture of one or more hydrogenotrophic bacteria, or contacting said site with a device comprising a composition comprising zero-valent iron and a culture of one or more hydrogenotrophic bacteria." Thus, since Weather does not teach or disclose a method of denitrification as in claim 35, Applicants believe that the rejection of claim 35 is improper.

The Action further contends claims 43-45 are anticipated by Weathers. Applicants respectfully submit that Weathers discloses remediation of only chloroform and does not teach the invention of claims 43-45. In order for a prior art to anticipate the claimed invention, the prior art must teach all elements of the claimed invention. Respectfully, Weathers does not provide the claim limitations of claims 43-45 and therefore cannot anticipate those claims.

With regards to claim 56, Applicants respectfully submit that claim 56 is not anticipated by Weathers. Present claim 56 recites "A method for reducing the concentration of a pesticide or organic pollutant in an aqueous solution or environmental site, comprising (a) selecting an aqueous solution or an environmental site containing said pesticide or pollutant; and (b) contacting said solution or site with a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria, or contacting said solution or site with a device comprising a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria." Claim 56 does not contain the limitation that chloroform be remediated. Applicants also point out that the Action acknowledges that Weathers does not disclose a specific bacteria rather, Weathers discloses a "mixed-culture."

Applicants also point out that Weathers does not teach or disclose a selecting or contacting step as is claimed in claim 56.

Thus, in light of all of the foregoing, Applicants respectfully request that the Examiner reconsider and withdraw the rejection of claims 1-3, 5-8, 13-18, 35, 42-45, and 56 under 35 U.S.C. 102(b) as being anticipated by Weathers (Applicants' reference C38).

C. The Rejection of Claim 4 under 35 U.S.C. §103 in view of Weathers and Semp is Overcome.

Claim 4 is rejected under U.S.C. 103(a) as being unpatentable over Weathers in view of Semp *et al.* Applicants respectfully traverse this rejection.

The Action acknowledges that Weathers does not disclose using one of the specified bacteria. The Action also contends that Semp *et al.* disclose using *Paraccocus denitrificans* ATCC 19367 in order to reduce nitrates. The Action further contends that it would have been obvious for the skilled artisan to have modified the device of Weathers such that it comprises *Paraccocus denitrificans* ATCC 19367 in order reduce nitrates in the water, as suggested by Semp *et al.*

Both Weathers and Semp *et al.*, are insufficient to create a *prima facie* case of obviousness against claim 4. To establish a *prima facie* case of obvious three criteria must be met: **1)** there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings; **2)** there must be a reasonable expectation of success; **3)** the prior art reference (or references when combined) must teach or suggest **all** the claim limitations.

MPEP §2143.03 and *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir.1991). See also MPEP §2143.03, citing *In re Royka*, 490 F.2d 981, 180 USPQ 580 (CCPA 1974).

Furthermore, that one or more references can be combined or modified is not sufficient to establish obviousness. For example, the Federal Circuit held in *In re Mills*, 916 F.2d 680, 16 U.S.P.Q.2d 1430 (Fed. Cir. 1990), that the mere fact that combination or modification of a reference or references is possible does not establish obviousness of the resultant combination unless the prior art ***also suggests*** the desirability of the combination, *i.e.*, unless the prior art provides ***motivation*** to produce the resultant combination. *Mills*, 16 U.S.P.Q.2d at 1432; *see also* MPEP § 2143.01, page 2100-91.

Moreover, the Board of Patent Appeals and Interferences has held that the fact that the claimed invention is within the capabilities of one of ordinary skill in the art is not sufficient by itself to establish obviousness. *Ex parte Levengood*, 28 U.S.P.Q.2d 1300 (BPAI 1993). Section 2143.01 of the MPEP explains the *Levengood* holding as follows: "A statement that modifications of the prior art to meet the claimed invention would have been 'well within the ordinary skill of the art' at the time the claimed invention was made'" because the references relied upon teach that all aspects of the claimed invention were individually known in the art is not sufficient to establish a *prima facie* case of obviousness without some objective reason to combine the teachings of the references."

Applicants respectfully submit that there is no motivation to combine the Weathers reference and the Semp *et al.*, reference. The Action acknowledges that Weathers does not disclose using a specific bacteria. Furthermore, Semp *et al.*, teaches an improved process for the microbial reduction of nitrate in tobacco materials via dissimilatory denitrification, which is not the process, compositions, or methods of the present invention. Weathers does not teach the

reduction of nitrate or denitrification. Thus, neither Weathers nor Semp *et al* teach a device of the claimed invention, but crucially, neither reference alone or together would suggest or lead the artisan to the present invention. The artisan would not have been motivated to combine the Weathers reference and the Semp *et al.*, reference to modify the device of Weathers since Weathers does not specify a device. There is simply no nexus between the two disclosures that would suggest to the ordinary artisan to combine them in an attempt to make the present invention.

Furthermore, a person of ordinary skill in the art would not have a reasonable expectation of achieving the claimed invention based on the combination of the two references cited given that no specific device was disclosed by Weathers that would be combined with the bacteria of Semp *et al.*

Applicants further respectfully point out that in order to support an obviousness rejection, **all** the claim limitations must be taught or suggested as cited in the MPEP §2143.03 and *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir.1991). Applicants contend that the Weathers reference in view of the Semp *et al.* reference does not teach the claim limitations of the device of claim 4. Applicants therefore believe that the obviousness rejection of claim 4 has been overcome.

Thus, in light of all of the foregoing, Applicants respectfully request that the Examiner reconsider and withdraw the reject ion of claim 4 under 35 U.S.C. §103.

CONCLUSION

Applicants believe that the foregoing remarks fully respond to all outstanding matters for this application. Applicants respectfully request that the rejections of all claims be withdrawn so they may pass to issuance.

Should the Examiner desire to sustain any rejections discussed in relation to this Response, the courtesy of a telephonic conference between the Examiner, the Examiner's supervisor, and the undersigned attorney at (512) 536-3043 is respectfully requested.

Respectfully submitted,

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Date: December 30, 2002

APPENDIX A:

MARKED COPY OF CLAIMS WITH APPROPRIATE EDITING INDICIA

1. (Amended) A device comprising a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria.

9. (Amended) A [The] device comprising a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria comprised [of claim 1], comprised within an environmental site.

11. (Amended) The device of claim 9 [1], further defined as an *in situ* reactive barrier.

42. (Amended) A method for removing or reducing the concentration of a halocarbon compound in a sample, comprising contacting a sample suspected of containing said halocarbon with a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria, or contacting said site with a device comprising a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria.

56. (Amended) A method for reducing the concentration of a pesticide or organic pollutant in an aqueous solution or environmental site, comprising (a) selecting an aqueous solution or an environmental site containing said pesticide or pollutant; and (b) contacting said solution or site with a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria, or contacting said solution or site with a device comprising a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria.

APPENDIX B: COPY OF PENDING CLAIMS AFTER AMENDMENTS

1. A device comprising a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria.

2. The device in accordance with claim 1, wherein said hydrogenotrophic bacteria comprise one or more species of bacteria selected from the group consisting of *Acetobacterium* spp., *Achromobacter* spp., *Aeromonas* spp., *Acinetobacter* spp., *Aureobacterium* spp., *Bacillus* spp., *Comamonas* spp., *Dehalobacter* spp., *Dehalospirillum* spp., *Dehalococcoide* spp., *Desulfurosarcina* spp., *Desulfomonile* spp., *Desulfobacterium* spp., *Enterobacter* spp., *Hydrogenobacter* spp., *Methanosarcina* spp., *Pseudomonas* spp., *Shewanella* spp., *Methanosarcina* spp., *Micrococcus* spp., and *Paracoccus* spp.

3. The device of claim 2, wherein said hydrogenotrophic bacteria comprise one or more strains of bacteria selected from the group consisting of *Acetobacterium woodi*, *Aeromonas hydrophila*, *Aeromonas sobria*, *Alcaligenes eutrophus*, *Comamonas acidovorans*, *Dehalococcoide restrictus*, *Dehalococcoide multivorans*, *Dehalococcoide ethenogene*, *Desulfobacterium tiedje*, *Enterobacter agglomerans*, *Hydrogenobacter thermophilus*, *Methanosarcina barkeri*, *Methanosarcina mazei*, *Methanosarcina thermophila*, *Paracoccus denitrificans*, *Pseudomonas aureofaciens*, *Pseudomonas maltophilia*, *Pseudomonas mendocina*, and *Shewanella putrefaciens*.

4. The device of claim 3, wherein said hydrogenotrophic bacteria comprise *Paracoccus denitrificans* ATCC17741, *Paracoccus denitrificans* ATCC35512, *Paracoccus denitrificans* ATCC13543, or *Paracoccus denitrificans* ATCC19367.

5. The device of claim 1, wherein said zero-valent iron comprises Fe(0) metal, an Fe(0) alloy, or an Fe(0)-Ni(0), Fe(0)-Zn(0), Fe(0)-Pt(0), or Fe(0)-Pd(0) bimetal.

6. The device of claim 5, wherein said zero-valent iron comprises filings, shavings, turnings, wool, powder, mesh, beads, rods, pellets, or flakes.

7. The device of claim 1, further comprising a support.

8. The device of claim 7, further comprising a glass, concrete, metallic, zeolite, mineral, fiber, fiberglass, ceramic, plastic, polymeric, or resin support.

9. A device comprising a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria comprised within an environmental site.

10. The device of claim 9, comprised within a landfill site, an agricultural site, an agricultural runoff site, or an irrigation site.

11. The device of claim 9, further defined as an *in situ* reactive barrier.

12. The device in accordance with claim 11, further defined as a permeable barrier, a semipermeable barrier, a treatment wall, and injected treatment zone, or a funnel and gate system.

13. The device of claim 1, further defined as an *ex situ* bioreactor.

14. The device in accordance with claim 13, comprising an inlet port, an outlet port and a container means for containing said composition.

15. The device of claim 14, further defined as a continuous culture system, a flow-through packed column, an inline water filter, a biofermenter, a fluidized bed, a sequencing batch reactor, or an anaerobic digester.

16. The device of claim 15, comprised within a water-, wastewater- or sewage-treatment system.

17. The device in accordance with claim 16, comprised within a water treatment system, a sewage or wastewater treatment system, a municipal water supply system, or a pollution decontamination system.

18. The device of claim 1, comprised within a system for remediating pollution in an aqueous solution or an environmental site.

34. A method of removing or reducing the concentration of an organic or inorganic compound in an environmental site, comprising providing to said site an effective amount

of a composition comprising zero-valent iron and a culture of one or more hydrogenotrophic bacteria, or contacting said site with a device comprising a composition comprising zero-valent iron and a culture of one or more hydrogenotrophic bacteria.

35. A method for denitrifying groundwater or an environmental site *in situ* comprising contacting said groundwater or said environmental site with a composition comprising zero-valent iron and a culture of one or more hydrogenotrophic bacteria, or contacting said site with a device comprising a composition comprising zero-valent iron and a culture of one or more hydrogenotrophic bacteria.

36. A method for removing or reducing the concentration of a nitrogen- or sulfur-containing compound in a sample, comprising contacting a sample suspected of containing said compound with a composition comprising zero-valent iron and a culture of one or more hydrogenotrophic bacteria, or contacting said site with a device comprising a composition comprising zero-valent iron and a culture of one or more hydrogenotrophic bacteria.

37. The method in accordance with claim 36, wherein said sulfur-containing compound is sulfate or sulfite.

42. A method for removing or reducing the concentration of a halocarbon compound in a sample, comprising contacting a sample suspected of containing said halocarbon with a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria, or contacting said site with a device comprising a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria.

43. The method in accordance with claim 42, wherein said halocarbon is carbon tetrachloride, dichloromethane, a polychlorinated biphenyl, a chlorinated benzene, trichloroethylene, perchloroethylene, dichloroethylene, vinyl chloride, chloroethane, bromoform, dichlorodifluoromethane, trihalomethanes, tetrachlorodibenzodioxin pentachlorophenol, a chlorobenzoate, atrazine, or 1,1,1-TCA.

44. The method of claim 43, wherein said halocarbon is carbon tetrachloride, dichloromethane, trichloroethylene, perchloroethylene, dichloroethylene, vinyl chloride,

chloroethane, dichlorodifluoromethane, trihalomethanes, tetrachlorodibenzodioxin pentachlorophenol, a chlorobenzoate, atrazine, or 1,1,1-TCA.

45. The method of claim 44, wherein said halocarbon is carbon tetrachloride, trichloroethylene, or dichloromethane.

46. A method for removing or reducing the concentration of a haloaromatic compound in a sample, comprising contacting a sample suspected of containing said haloaromatic compound with a composition comprising zero-valent iron and a culture of one or more hydrogenotrophic bacteria, or contacting said sample with a device comprising a composition comprising zero-valent iron and a culture of one or more hydrogenotrophic bacteria.

47. The method in accordance with claim 46, wherein said haloaromatic compound is a polychlorinated biphenyl, a chlorinated benzene, tetrachlorodibenzodioxin pentachlorophenol, a chlorobenzoate, atrazine, or 1,1,1-TCA.

48. A method for degrading or detoxifying a pesticide, comprising contacting a sample suspected of containing said pesticide with a composition comprising zero-valent iron and a culture of one or more hydrogenotrophic bacteria, or contacting said sample with a device comprising a composition comprising zero-valent iron and a culture of one or more hydrogenotrophic bacteria.

49. The method in accordance with claim 48, wherein said pesticide is methoxyclor, alachlor, metolachlor, lindane, DDT, DDE, DDD, dieldrin, aldrin, heptachlor, chlordane, 2,4-dichlorophenoxyacetic acid, 2,4,5-trichlorophenoxyacetic acid or atrazine.

50. The method of claim 49, wherein said pesticide is atrazine.

51. A method for detoxifying a metal ion-containing compound, comprising contacting a sample suspected of containing said compound with a composition comprising zero-valent iron and a culture of one or more hydrogenotrophic bacteria, or contacting said sample with a device comprising a composition comprising zero-valent iron and a culture of one or more hydrogenotrophic bacteria.

52. The method in accordance with claim 51, wherein said compound comprises strontium (II), cesium (I), chromium (VI) uranium (VI), technetium (VII), silver (I), or mercury (II).

53. The method of claim 52, wherein said compound comprises chromium (VI) or uranium (VI).

54. A method for reducing the concentration of nitrite-, nitrate-, sulfite-, or sulfate-containing compound in an aqueous solution or environmental site, comprising (a) selecting an aqueous solution or an environmental site containing said compound; and (b) contacting said solution or site with a composition comprising zero-valent iron and a culture of one or more hydrogenotrophic bacteria, or contacting said solution or site with a device comprising a composition comprising zero-valent iron and a culture of one or more hydrogenotrophic bacteria.

56. A method for reducing the concentration of a pesticide or organic pollutant in an aqueous solution or environmental site, comprising (a) selecting an aqueous solution or an environmental site containing said pesticide or pollutant; and (b) contacting said solution or site with a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria, or contacting said solution or site with a device comprising a composition comprising zero-valent iron and a culture of one or more autotrophic hydrogenotrophic bacteria.

57. A method for reducing the concentration of a mercury-, silver-, technetium-, strontium-, cesium-, chromium- or uranium-containing pollutant in an aqueous solution or environmental site, comprising (a) selecting an aqueous solution or an environmental site containing said pollutant; and (b) contacting said solution or site with a composition comprising zero-valent iron and a culture of one or more hydrogenotrophic bacteria, or contacting said solution or site with a device comprising a composition comprising zero-valent iron and a culture of one or more hydrogenotrophic bacteria.

58. A method for reducing silver (I), mercury (II), technetium (VII), strontium (II), cesium (I), chromium (VI) or uranium (VI) ions in an aqueous solution, comprising contacting an

aqueous solution suspected of containing one or more of said ions with a composition comprising zero-valent iron and a culture of one or more hydrogenotrophic bacteria, or contacting said aqueous solution with a device comprising a composition comprising zero-valent iron and a culture of one or more hydrogenotrophic bacteria.

APPENDIX C: COPY OF THE ABSTRACT

Please insert the following Abstract on a separate page following the claims in the specification.

ABSTRACT

--Disclosed are methods, devices and apparatus for bioremediation of mixed waste aquifers, based on a synergistic combination of reductive treatment using zero-valent iron and anaerobic biotransformations. Also disclosed are methods for *in situ* and *ex situ* remediation of groundwater and wastewater *via* these iron-bacterial compositions in a variety of devices including batch reactors, permeable and semipermeable reactive barriers, flow-through reactors, fluidized bed reactors, and sediment tanks. --